Docket No.: 50103-404

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

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In re Application of	Customer Number: 20277
Chung-Hee CHANG, et al.	Confirmation Number: 4803
Serial No.: 09/986,063	Group Art Unit: 1773
Filed: November 07, 2001	Examiner: Louis V. Falasco

For: PERPENDICULAR MAGNETIC RECORDING MEDIA WITH IMPROVED INTERLAYER

TRANSMITTAL OF APPEAL BRIEF

Mail Stop Appeal Brief Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Submitted herewith in triplicate is Appellant(s) Appeal Brief in support of the Notice of Appeal filed concurrently herewith. Please charge the Appeal Brief fee of $320.00 to Deposit Account 500417.

To the extent necessary, a petition for an extension of time under 37 C.F.R. 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account 500417 and please credit any excess fees to such deposit account.

Respectfully submitted,

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Date: August 27, 2003

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#7

APPEAL BRIEF

Mail Stop Appeal Brief Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This Appeal Brief is submitted in support of the Notice of Appeal filed concurrently herewith.

I. REAL PARTY IN INTEREST

The real party in interest is Seagate Technology LLC.

II. RELATED APPEALS AND INTERFERENCES

Appellants are unaware of any related appeals and interferences.

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III. STATUS OF CLAIMS

Claims 1 - 20 are pending in this application. Of these, claims 14 - 18 stand withdrawn from consideration as a result of a requirement for restriction. Accordingly, claims 1 - 13 and 19 - 20 are active in this application, which claims 1 - 13 and 19 - 20 stand finally rejected. It is from the final rejection of claims 1 - 13 and 19 - 20 that this appeal has been taken.

IV. STATUS OF AMENDMENTS

No amendments to the application have been made.

V. SUMMARY & BACKGROUND OF THE INVENTION

The claimed invention, per independent claims 1 and 19, is directed to a low noise, high areal recording density, perpendicular magnetic recording medium, comprising a layer stack formed over a surface of a non-magnetic substrate, the layer stack including, in overlying sequence from the substrate surface: a magnetically soft underlayer, at least one non-magnetic interlayer, and a CoCr-based, magnetically hard perpendicular recording layer, *wherein* the compositions of the at least one non-magnetic interlayer and the CoCr-based, magnetically hard perpendicular recording layer are selected to provide the medium with:

1. a negative nucleation field H_n;
2. remanent squareness of about 1; and
3. a high coercivity of at least about 5,000 Oe.

The invention addresses and solves problems attendant upon the use of CoCr-based magnetically hard recording layers in the design and manufacture of high bit density perpendicular magnetic recording media, e.g., noise generation, which adversely affects the

signal-to-media noise ration (SMNR) of such media, while at the same time maintaining all structural and mechanical aspects of high bit density magnetic recording technology, and allowing for manufacture of the inventive media by means of conventional fabrication techniques, such as sputtering.

More specifically, a description of the state of the art of perpendicular magnetic recording media *at the time of appellants' invention* is given at page 4, line 12 through page 6, line 2 of the instant specification, and is reproduced below:

> "Another way of classifying perpendicular magnetic recording media into different types is based on the media properties provided by the material utilized for the magnetically hard recording layer. For example, as indicated above, the magnetically hard, perpendicular recording layer can comprise magnetic alloys which are typically employed in longitudinal media, e.g., CoCr alloys, or multi-layer magnetic superlattice structures, such as the aforementioned $(CoX/Pd \text{ or } Pt)_n$ superlattice structures. Representative M-H hysteresis loops of magnetic recording layers comprised of these different types of materials are shown in FIG. 2(A) - 2(B). As is evident from FIG. 2(A) showing the M-H loop of a perpendicular recording medium comprising a CoCr alloy, such type media typically exhibit a relatively low coercivity, low remanent squareness, i.e., less than 1, and a positive nucleation field H_n. In addition, the occurrence of magnetic domain reversal within bits, caused by the presence of high demagnetization fields in CoCr-based perpendicular recording media, is problematic with such media in that the phenomenon is a significant source of media noise reducing the SMNR. A high remanent squareness and a negative nucleation field H_n are required in order to obtain good bit stability.
>
> By contrast, and as evidenced by FIG. 2(B) showing the M-H loop of a perpendicular recording medium comprising a $(CoX/Pd)_n$ multilayer magnetic superlattice structure, such type media advantageously exhibit a relatively high coercivity, remanent squareness of about 1, and a negative nucleation field H_n, which characteristics are attributed to the high anisotropy energy of such type media arising from interfacial anisotropy effects. However, the grains of the multilayer magnetic superlattice structure tend to experience exchange coupling leading to transition noise. Moreover, notwithstanding the possibility of further improvements in multilayer magnetic superlattice structures for use in the fabrication of high recording density magnetic media, significant current issues/problems remain pertaining to the ability to manufacture such structures in a commercially viable manner.
>
> It is believed that high areal recording densities of about 200 Gbit/in^2 or greater are possible with perpendicular magnetic media utilizing CoCr-based magnetic alloys as the magnetically hard recording

layer. However, the obtainment of such high areal recording densities requires CoCr-based perpendicular media which exhibit the advantageous properties associated with multilayer magnetic superlattice-based media, i.e., high coercivity, remanent squareness of about 1, and a negative nucleation field H_n.

In view of the above, there exists a clear need for improved, high areal recording density, perpendicular magnetic information/data recording, storage, and retrieval media including CoCr-based magnetically hard recording layers, but which exhibit substantially increased signal-to-media noise ratios (SMNR), high coercivity, remanent squareness of about 1, and a negative nucleation field H_n. In addition, there exists a need for an improved method for manufacturing high areal recording density, perpendicular magnetic recording media employing CoCr-based magnetically hard recording layers which exhibit substantially increased SMNR, high coercivity, remanent squareness of about 1, and a negative nucleation field H_n, which media can be readily and economically fabricated by means of conventional manufacturing techniques and instrumentalities".

A key feature, therefore, of the instant invention, is the determination and selection of particular magnetic alloy compositions and non-magnetic interlayer structures for providing CoCr magnetic alloy-based perpendicular recording media with desirable characteristics *similar* to those of multilayer magnetic superlattice-based perpendicular recording media, while avoiding the difficulties associated with manufacture of the latter type media.

Dependent claims 2 - 10 and 13 recite specific materials, requirements, and thicknesses of component layers according to a number of possible layer stack constructions affording the desirable magnetic performance characteristics of the media defined in claim 1, as follows:

Claim 2 indicates that the at least one non-magnetic interlayer is not more than about 10 nm thick;

Claim 3 indicates three possibilities for the at least one non-magnetic interlayer, i.e., a Ru layer, a Ru/CoCr bi-layer structure, and a Ru/CoCrX bi-layer structure, where X is at least one element selected from among Pt, Ta, Mo, Ti, W, Ag, and Pd;

Claim 4 specifies the at least one non-magnetic interlayer as a Ru/CoCr bi-layer structure,

wherein the Cr content of the CoCr portion is from about 37 to about 43 at. %;

Claim 5 specifies the at least one non-magnetic interlayer as a Ru/CoCrX bi-layer wherein the Co content of the CoCrX is from about 57 to about 63 at. %;

Claim 6 indicates the CoCr-based magnetically hard perpendicular recording layer as comprising a CoCrPt alloy layer from about 10 to about 30 nm thick;

Claim 7 specifies the Pt content in the CoCrPt alloy as from about 14 to about 21 at. %;

Claim 8 further specifies the Pt content in the CoCrPt alloy as about 15 at. % and the Cr content as about 20 at %;

Claim 9 indicates that the magnetically soft layer is about 150 to about 400 nm thick and comprised of a material selected from among Ni, NiFe, Co, CoZr, CoZrCr, CoZrNb, CoTaZr, CoFe, Fe, FeN, FeSiAl, FeSiAlN, FeTaC, FeAlN, FeTaN, CoFeZr, and FeCoB;

Claim 10 specifies the magnetically soft underlayer as comprising FeCoB; and

Claim 13 recites specific combinations of layer stack structures comprised of:

(1) a magnetically soft underlayer from about 150 to 400 nm thick and comprised of FeCoB;

(2) a non-magnetic interlayer not greater than about 10 nm thick, comprised of a Ru layer, a Ru/CoCr bi-layer structure, or a Ru/CoCrX bi-layer structure, where X is at least one element selected from among Pt, Ta, Mo, Ti, W, Ag, and Pd; and

(3) a magnetically hard perpendicular magnetic recording layer about 25 nm thick and comprised of a CoCrPt alloy with about 20 at. % Cr and 15 at. % Pt.

VI. ISSUES

A. The Rejection

Claims 1 - 13 and 19 - 20 stand finally rejected under 35 USC § 103 (a) for obviousness predicated upon a combination of "the admitted state of the prior art" taken with U.S. Patent 5,851,643 (Honda et al.) and U.S. Patent 6,403,203 (Futamoto et al.).

B. The Issue Which Arises in This Appeal and Requires Resolution by The Honorable Board is:

Whether claims 1 - 13 and 19 - 20 are unpatentable under 35 USC § 103 (a) for obviousness predicated upon a combination of "the admitted state of the prior art" taken with U.S. Patent 5,851,643 (Honda et al.) and U.S. Patent 6,403,203 (Futamoto et al.).

VII. GROUPING OF CLAIMS

The appealed claims do not stand or fall together. Specifically, appellants exercise their right to separately argue the patentability of claims 1 - 3, 6, 9 - 12, and 19 - 20 as a first group, claim 4 as a second group, claim 5 as a third group, claim 7 as a fourth group, claim 8 as a fifth group, and claim 13 as a sixth group.

VIII. THE ARGUMENT

A. The Examiner's Position

In stating the basis for rejection of claims 1 - 13 and 19 - 20 (as given in the first Office Action of March 3, 2003) as unpatentable under 35 USC 103 § for obviousness "over the admitted state of the prior art taken with Honda et al. (US 5,851,643) in view of Futamoto et al. (US 6,403,203)," the Examiner opined that "it would have been obvious to one having ordinary skill in the art at the time the invention was made to adopt the perpendicular recording

compositions of Honda et al in the admittedly conventional perpendicular recording media and make adjustments as to characteristic crystal sizes, alloy blends and layer thickness shown by Futamoto et al for the purpose of controlling the sensitivity and coercivity of the perpendicular recording media."

B. Appellants' Position

Appellants strenuously disagree with the imposed rejection of claims 1 - 13 and 19 - 20 as unpatentable under 35 USC § 103 (a) predicated upon the above combination of "the admitted prior art" and the Honda et al. and Futamoto et al. references, for the following reasons:

It is urged that, apart from appellants' own teachings contained in the instant specification, neither "the admitted prior art", nor any of the applied references demonstrates even a scintilla of recognition of the problems associated with prior CoCr alloy-based perpendicular magnetic recording media. In addition, the Examiner's analysis of the "admitted prior art" as described in the instant specification does not appear to give full consideration of the true "state of the art" pertaining to CoCr alloy-based perpendicular magnetic recording media, *at the time the invention was made.* Specifically, at the time of appellants' invention, known CoCr-based perpendicular magnetic recording media were inferior to $(CoX/Pd)_n$ superlattice-based magnetic media in regard to several characteristics considered critical in obtaining high performance, low noise, perpendicular magnetic recording media, including high coercivity, remanent squareness approaching 1, and a negative nucleation field H_n. However, the manufacture of $(CoX/Pd)_n$ superlattice-based magnetic media entails several difficulties and/or drawbacks, primarily due to difficulty in depositing the large number n of (CoX/Pd) layer pairs

required for the superlattice (i.e., n = 10 - 25), as well as the high manufacturing cost associated therewith.

By contrast, very high areal recording densities of about 200 Gbit/in^2 are considered possible with CoCr-based perpendicular magnetic recording media, which CoCr-based media can be manufactured at lower cost than the superlattice-based media. However, conventionally structured CoCr-based perpendicular magnetic recording media typically exhibit relatively low coercivities and remanent squareness, as well as positive nucleation fields. In addition, magnetic domain reversal within bits is problematic in causing media noise reducing the SMNR.

In view of the foregoing, it is evident that an ideal perpendicular magnetic recording medium is one which combines the high areal recording densities possible with CoCr-based perpendicular media (as well as the ease of manufacture) and the advantageous recording properties associated with multilayer magnetic superlattice-based media, i.e., high coercivity (5,000 Oe or greater), remanent squareness of about 1, and a negative nucleation field H_n.

The present invention advantageously and unexpectedly achieves such result, i.e., CoCr-based perpendicular magnetic recording media having the high areal recording densities and lower manufacturing costs associated therewith while simultaneously exhibiting the high performance characteristics associated with $(CoX/Pd)_n$ superlattice-based media. According to the invention, CoCr-based perpendicular magnetic recording media exhibiting the advantageous properties of $(CoX/Pd)_n$ superlattice-based media (i.e., negative nucleation field, remanent squareness approaching 1, and high coercivity of at least about 5,000 Oe) are provided by utilizing specific combinations of at least one non-magnetic interlayer and the CoCr-based perpendicular magnetic recording layer.

As for the Honda et al. and Futamoto et al. references relied upon by the Examiner in positing obviousness of the instantly claimed subject matter, the Examiner cites various portions of the reference as disclosing various materials and alloy compositions utilized for the various layers of perpendicular magnetic recording media, as well as variation of their thicknesses for adjustment of the performance characteristics of the media. Appellants strongly disagree with the Examiner's characterization of the instantly claimed invention as resulting from "mere selection" of appropriate materials and thicknesses of the magnetically soft underlayer, non-magnetic interlayer, and magnetically hard perpendicular recording layer from those disclosed by the applied references. Specifically, appellants vigorously contest the Examiner's stated position that "the materials selected have been known in the art for perpendicular magnetic recording media and the selection of thickness are taught to be a matter of choice".

The Examiner's analysis manifestly fails to take into account the <u>unexpected result</u> provided by the instantly claimed invention, which result could not reasonably be expected or predicted from the applied references, i.e., obtainment for the first time of readily manufactured CoCr-based perpendicular magnetic recording media exhibiting the advantageous performance characteristics associated with difficult-to-manufacture $(CoX/Pd)_n$ superlattice-based media. Specifically, since both Honda et al. and Futamoto et al. are essentially concerned with the formation of magnetic recording media wherein the recording layer is comprised of a stacked or laminated plurality of perpendicular magnetic recording layers, <u>as opposed to</u> the instantly claimed high coercivity, high remanent squareness, negative nucleation field, CoCr alloy-based perpendicular magnetic recording media, <u>nothing in either Honda et al. and Futamoto et al. indicates or remotely suggests</u> that <u>any combination</u> of at least one non-magnetic interlayer <u>and</u> a CoCr-based perpendicular magnetic recording layer, <u>each having a specific composition</u>, can

provide improved perpendicular magnetic recording media having a negative nucleation field H_n, remanent squareness approaching 1, and a high coercivity of at least about 5,000 Oe. By contrast, Honda et al. disclose formation of perpendicular magnetic recording media with substantially lower coercivities, i.e., on the order of 2,000 Oe (see, e.g., Col. 4, lines 55-58) and Futamoto et al. disclose substantially lower coercivities, on the order of about 3,100 Oe (see Table 4), which relatively low coercivities are characteristic of the prior CoCr-based perpendicular media. In addition, Honda et al. and Futamoto et al. are conspicuously silent with respect to the advantage of forming CoCr-based perpendicular magnetic with a negative nucleation field H_n and remanent squareness approaching unity, each indicative of high anisotropy energy arising from interfacial anisotropy effects.

As a consequence, the instantly claimed invention is not a mere result of "routine optimization", i.e., selection of appropriate materials and layer thicknesses as "a matter of choice" as posited by the Examiner. It therefore is not evident to appellants how the teachings of the "admitted prior art" and the Honda et al and Futamoto et al. references can be reasonably considered as guidance in arriving at the claimed invention, or utilized, singly or in any possible combination, to arrive at the instantly claimed invention. In point of fact, the instantly claimed invention, wherein improved perpendicular magnetic recording media having the advantages of high areal recording density and ease of manufacture of CoCr-based media and the advantageous performance characteristics of superlattice-based media are provided, constitutes a significant advance over the prior art of record, which advance could not have reasonably been expected or predicted from the "admitted state of the art" taken in any possible combination with the teachings of the applied references Honda et al. and Futamoto et al.

It is additionally noted that the failure of the prior art to address or offer a solution to the

problems (i.e., low coercivity, poor remanent squareness, positive nucleation field, etc.) associated with CoCr alloy-based perpendicular magnetic recording media, which problems are addressed and effectively remedied by the present invention, underscores the unobviouness of the claimed invention as a whole. *In re Newell*, 7 USPQ 2d 1248; *In re Nomiya*, 184 USPQ 607.

In view of the foregoing, it is manifestly evident that in the original or subsequent statement of the basis for rejection of the claims, the Examiner did not in fact succeed in carrying forth his required initial burden of establishing a *prima facie* case of obviousness of the instantly claimed invention under 35 USC § 103 (a).

Moreover, in the second Official Action (Final Rejection), the Examiner again considered Honda et al. as (broadly) teaching the materials of the instant media (albeit in the different context of media with a laminated magnetic recording layer), which teaching is apparently considered by the Examiner as to preclude patentability of all magnetic media (even unexpectedly well-performing media) resulting from determination and selection of particular materials compositions and combinations thereof in the layer stack. However, as in the previous (first) rejection, the Examiner fails to indicate *precisely how* a routineer would be led by the "admitted prior art" taken in combination with the reference disclosures to arrive at the particular materials for the at least one non-magnetic interlayer and CoCr magnetic recording layer which provide the unexpected, advantageous performance characteristics of the claimed media. In addition, in the last paragraph of the Final Rejection (issued June 26, 2003), the Examiner appears to regard the invention as the result of selected "material combinations and layer thickness that does not appear in any single claim under consideration". It is respectfully urged that this statement is clearly erroneous in view of claim 13, which claim recites specific thicknesses and compositions for each of the pertinent constituent layers of the layer stack.

As for claims 4, 5, 7, 8, and 13, the patentability of each is separately argued. Specifically, neither the "admitted prior art" or either of the applied references discloses or even remotely suggests use of a Ru/CoCr bi-layer structure as in claim 4, wherein the Cr content of the CoCr portion is from about 37 to about 43 at. %; neither the "admitted prior art" or either of the applied references discloses or even remotely suggests use of a Ru/CoCrX bi-layer structure as in claim 5, wherein the Co content of the CoCrX portion is from about 57 to about 63 at. %; neither the "admitted prior art" or either of the applied references discloses or even remotely suggests use of a CoCrPt alloy as in claim 7, wherein the Pt content is from about 14 to about 21 at. %; neither the "admitted prior art" or either of the applied references discloses or even remotely suggests use of a CoCrPt alloy as in claim 8, wherein the Cr content is about 20 at. % and the Pt content is from about 15 at. %; and neither the "admitted prior art" or either of the applied references discloses or even remotely suggests use of the particular combination of a magnetically soft underlayer comprised of an about 150 to about 400 nm thick layer of FeCoB, a non-magnetic interlayer not greater than about 10 Å thick, selected from a Ru layer, a Ru/CoCr bi-layer structure, and a Ru/CoCrX bi-layer structure, where X is at least one element selected from among Pt, Ta, Mo, Ti, W, Ag, and Pd, and a perpendicular magnetic recording layer about 25 nm thick and comprised of a CoCrPt alloy with about 20 at. % Cr and about 15 at. % Pt.

Appellants, therefore, respectfully submit that the imposed rejection of claims 1 - 13 and 19 - 20 under 35 USC § 103 (a) for obviousness predicated upon a combination of "the admitted prior art" in view of Honda et al. and Futamoto et al. is neither factually or legally viable.

IX. CONCLUSION

The "admitted prior art", taken in view of the applied references (Honda et al. and

Futamoto et al.), taken in any possible combination, do not recognize, disclose, suggest, or otherwise render obvious the instantly claimed CoCr alloy-based perpendicular magnetic recording media which exhibit significantly improved magnetic performance characteristics vis-à-vis prior CoCr alloy-based perpendicular media, including a negative nucleation field Hn, a remanent squareness of about 1, and a high coercivity of at least about 5,000 Oe, which characteristics have hitherto been obtainable only with expensive, difficult-to-fabricate superlattice-based perpendicular magnetic recording media. In making the rejection for obviousness of claims 1 - 13 and 19 - 20 under 35 USC § 103 (a) predicated upon a combination of "the admitted prior art" and the Honda et al. and Futamoto et al., the Examiner has merely demonstrated that the types of materials usable in fabricating magnetic recording media are known. However, the Examiner has manifestly failed to provide any evidence of recognition of the problems associated with CoCr alloy-based perpendicular magnetic recording media which are addressed and solved by the instant invention, nor has the Examiner demonstrated how the combination of "the admitted prior art" and the mere listings of known materials for magnetic recording media contained in the Honda et al and Futamoto et al. references realistically and inexorably lead to selection of the particular combinations of materials/structures for the non-magnetic interlayers and magnetic recording layers which facilitate manufacture of media with the advantageous performance characteristics according to the invention.

X. PRAYER FOR RELIEF

Appellants respectfully submit that the previously described shortcomings in the objective evidence, want of realistic motivation, and absence of guidance for selection of particular combinations of materials/structures, etc. for the constituent layers of CoCr alloy-based

perpendicular magnetic recording media for remedying the shortcomings of previous CoCr-based media, undermine the Examiner's stated conclusion that one having ordinary skill in the art would have made the subject matter as a whole, and defined in any of the rejected claims 1 - 13 and 19 - 20, obvious within the meaning of 35 USC § 103 (a). Appellants, therefore, respectfully solicit The Honorable Board to reverse the Examiner's rejection under 35 USC § 103 (a).

To the extent necessary, a petition for an extension of time under 37 CFR § 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account 500417 and please credit any excess fees to such deposit account.

Respectfully submitted,

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XI. APPENDIX

1. A low noise, high areal recording density, perpendicular magnetic recording medium, comprising:

(a) a non-magnetic substrate having a surface; and

(b) a layer stack formed over said substrate surface, said layer stack comprising, in overlying sequence from said substrate surface:

(i) a magnetically soft underlayer;

(ii) at least one non-magnetic interlayer; and

(iii) a CoCr-based, magnetically hard perpendicular recording layer;

wherein the compositions of said at least one non-magnetic interlayer and said CoCr-based, magnetically hard perpendicular recording layer are selected to provide said medium with a negative nucleation field H_n, remanent squareness of about 1, and high coercivity of at least about 5,000 Oe.

2. The magnetic recording medium as in claim 1, wherein:

said at least one non-magnetic interlayer (ii) is not more than about 10 nm thick.

3. The magnetic recording medium as in claim 2, wherein:

said at least one non-magnetic interlayer (ii) comprises a layer of Ru, a Ru/CoCr bi-layer structure, or a Ru/CoCrX bi-layer structure, where X is at least one element selected from the group consisting of Pt, Ta, Mo, Ti, W, Ag, and Pd.

4. The magnetic recording medium as in claim 3, wherein:

said at least one non-magnetic interlayer (ii) comprises a Ru/CoCr bi-layer structure, wherein the Cr content of the CoCr portion of said Ru/CoCr bi-layer structure is from about 37 to about 43 at. %.

5. The magnetic recording medium as in claim 3, wherein:

said at least one non-magnetic interlayer (ii) comprises a Ru/CoCrX bi-layer structure, wherein the Co content of the CoCrX portion of said Ru/CoCrX bi-layer structure is from about 57 to about 63 at. %.

6. The magnetic recording medium as in claim 1, wherein:

said CoCr-based, magnetically hard perpendicular recording layer (iii) is from about 10 to about 30 nm thick and comprises a CoCrPt alloy.

7. The magnetic recording medium as in claim 6, wherein:

said CoCr-based, magnetically hard perpendicular recording layer (iii) comprises a CoCrPt alloy with a Pt content from about 14 to about 21 at. %.

8. The magnetic recording medium as in claim 7, wherein:

said CoCrPt alloy comprises about 20 at. % Cr and about 15 at. % Pt.

9. The magnetic recording medium as in claim 1, wherein:

said magnetically soft underlayer (i) is from about 150 to 400 nm thick and comprises a material selected from the group consisting of: Ni, NiFe (Permalloy), Co, CoZr, CoZrCr, CoZrNb, CoTaZr, CoFe, Fe, FeN, FeSiAl, FeSiAlN, FeTaC, FeAlN, FeTaN, CoFeZr, and FeCoB.

10. The magnetic recording medium as in claim 9, wherein:

said magnetically soft underlayer (i) comprises FeCoB.

11. The magnetic recording medium as in claim 1, wherein:

said non-magnetic substrate (a) comprises a material selected from the group consisting of Al, NiP-plated Al, Al-Mg alloys, other Al-based alloys, other non-magnetic metals, other non-magnetic alloys, glass, ceramics, polymers, glass-ceramics, and composites and/or laminates thereof.

12. The magnetic recording medium as in claim 1, further comprising:

(c) a protective overcoat layer over said magnetically hard perpendicular recording layer (iii); and

(d) a lubricant topcoat over said protective overcoat layer.

13. The magnetic recording medium as in claim 1, wherein:

said non-magnetic substrate (a) comprises a material selected from the group consisting of Al, NiP-plated Al, Al-Mg alloys, other Al-based alloys, other non-magnetic metals, other non-magnetic alloys, glass, ceramics, polymers, glass-ceramics, and composites and/or laminates thereof; and said layer stack (b) comprises:

a magnetically soft underlayer (i) from about 150 to 400 nm thick and comprised of FeCoB;

a non-magnetic interlayer (ii) not greater than about 10 Å thick, comprised of a Ru layer, a Ru/CoCr bi-layer structure, or a Ru/CoCrX bi-layer structure, wherein X is at least one element selected from the group consisting of Pt, Ta, Mo, Ti, W, Ag, and Pd; and

a magnetically hard, perpendicular magnetic recording layer (iii) about 25 nm thick and comprised of a CoCrPt alloy with about 20 at. % Cr and about 15 at. % Pt; wherein said medium exhibits a high coercivity of about 5,000 Oe, a remanent squareness of about 0.98, and a negative nucleation field H_n of at least about -1,250 Oe.

14. (Withdrawn) A method of manufacturing a low noise, high areal recording density, perpendicular magnetic recording medium, comprising the steps of:

(a) providing a non-magnetic substrate having a surface; and

(b) forming a layer stack over said substrate surface, comprising steps for forming in overlying sequence from said substrate surface:

(i) a magnetically soft underlayer;

(ii) at least one non-magnetic interlayer; and

(iii) a CoCr-based, magnetically hard perpendicular recording layer;

wherein step (b) includes selecting the compositions of said at least one non-magnetic interlayer and said CoCr-based, magnetically hard perpendicular recording layer to provide said medium with a negative nucleation field H_n, remanent squareness of about 1, and high coercivity of at least about 5,000 Oe.

15. (Withdrawn) The method according to claim 14, wherein:

step (a) comprises providing a non-magnetic substrate comprised of a material selected from the group consisting of Al, NiP-plated Al, Al-Mg alloys, other Al-based alloys, other non-magnetic metals, other non-magnetic alloys, glass, ceramics, polymers, glass-ceramics, and composites and/or laminates thereof;

step (b)(i) comprises forming said magnetically soft underlayer as an about 150 to about 400 nm thick layer comprised of a material selected from the group consisting of: Ni, NiFe (Permalloy), Co, CoZr, CoZrCr, CoZrNb, CoTaZr, CoFe, Fe, FeN, FeSiAl, FeSiAlN, FeTaC, FeAlN, CoFeZr, and FeCoB;

step (b)(ii) comprises forming said at least one non-magnetic interlayer at a thickness not greater than about 10 nm and comprised of a layer of Ru, a Ru/CoCr bi-layer structure, or a Ru/CoCrX bi-layer structure, wherein X is at least one element selected from the group consisting of Pt, Ta, Mo, Ti, W, Ag, and Pd; and

step (b)(iii) comprises forming said CoCr-based, magnetically hard perpendicular recording layer as an about 10 to about 30 nm thick layer comprised of a CoCrPt alloy with a Pt content from about 14 to about 21 at. %.

16. (Withdrawn) The method according to claim 15, wherein:

step (b)(i) comprises forming a magnetically soft underlayer comprised of FeCoB;

step (b)(ii) comprises forming a non-magnetic interlayer wherein the portion of Co in the Ru/CoCr bi-layer structure or Ru/CoCrX bi-layer structure is from about 57 to about 63 at. %; and

step (b)(iii) comprises forming a magnetically hard, perpendicular magnetic recording layer (iii) about 25 nm thick and comprised of a CoCrPt alloy with about 20 at. % Cr and about 15 at. % Pt;

whereby said medium exhibits a high coercivity of about 5,000 Oe, a remanent squareness of about 0.98, and a negative nucleation field H_n of at least about -1,250 Oe.

17. (Withdrawn) The method according to claim 14, wherein:

each of steps (b)(i), (b)(ii), and (b)(iii) for respectively forming said magnetically soft underlayer, said non-magnetic interlayer, and said magnetically hard, perpendicular recording layer comprises DC magnetron sputtering; and the method further comprises heating said non-magnetic substrate between steps (b)(i) and (b)(ii) and between steps (b)(ii) and (b)(iii).

18. (Withdrawn) The method according to claim 14, further comprising steps of:

(c) forming a protective overcoat layer over said magnetically hard perpendicular recording layer; and

(d) forming a lubricant topcoat over said protective overcoat layer.

19. A low noise, high areal recording density, perpendicular magnetic recording medium, comprising:

(a) a perpendicular magnetic recording layer comprised of a CoCr alloy; and

(b) means for providing said medium with a negative nucleation field H_n, remanent squareness of about 1, and high coercivity of at least about 5,000 Oe.

20. A disk drive comprising the perpendicular magnetic recording medium of claim 1.